AD-A280 410

SYR. UNIV. CASE CENTER PK/PB 653 P02 MAY 10 '94 14:03

REPORT DOCUMENTATION PAGE

OMB No. 0704-0188

(1)

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March, 1994	Final Report, 15 JAN 93 - 14 JAN 94

4. TITLE AND SUBTITLE

DISTRIBUTED DETECTION THEORY & DATA FUSION (u)

5. FUNDING NUMBERS

2304/ES
61102F
F49620-93-1-0122

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DTIC ELECTE JUN 2 1 1994 S B D

94-18962

8. PERFORMING ORGANIZATION REPORT NUMBER

AFOSR-TR- 94 0365

ECETR-1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Office of Scientific Research
110 Duncan Avenue, Suite B 115
Bolling AFB, DC 20332

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

F49620-93-1-0122

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

APPROVED FOR Public RELEASE;
Distribution Unlimited

12b. DISTRIBUTION CODE

UL

13. ABSTRACT (Maximum 200 words)

Design of distributed order statistic constant false alarm rate (OS-CFAR) detection systems with data fusion was investigated. Its performance for different fusion rules and for a variety of nonhomogeneous backgrounds such as clutter edges and interfering targets was analyzed. Issues related to sampling and quantization in distributed detection systems were addressed. Sampling schemes for signal detection based on Ali-Silvey distance measures were derived. Performance enhancement over uniform sampling was shown. A number of collaborative research projects with Rome Laboratory engineers were carried out. The most notable one was the development of a prototype of an expert system CFAR (ES-CFAR) processor. This processor intelligently selects the CFAR algorithm based upon the observed characteristics of the environment. Substantial performance improvement over a conventional CFAR processor was demonstrated.

94 6 20 030

14. SUBJECT TERMS

Distributed Detection, Data Fusion, Detection Theory

15. NUMBER OF PAGES

4

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

AFOSR-TR- 94 0365

FINAL REPORT

DISTRIBUTED DETECTION THEORY AND DATA FUSION

(Grant No. F49620-93-1-0122)

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Design and analysis of multisensor signal processing systems has generated widespread interest. Advantages of these systems include higher reliability and survivability, enhanced system performance and shorter processing time. In this area, we continued our work on an important problem in the area of radar signal detection namely that of constant false alarm rate (CFAR) detection. Our earlier results had assumed a homogeneous background and in that case cell averaging (CA) CFAR detectors were used as peripheral detectors. In this work we employed order statistic (OS) CFAR detectors as peripheral detectors. We analyzed the performance of distributed OS-CFAR detection with data fusion both in homogeneous and nonhomogeneous backgrounds. System parameters were optimized assuming a homogeneous background under a fixed global probability of false alarm constraint. Then using these parameter values the performances of the systems were analyzed in nonhomogeneous background conditions where multiple target and clutter edge cases were considered. A number of interesting practical scenarios were investigated and performance results for different fusion rules were obtained. These results are provided in [1,2]. A number of other CFAR detection problems were solved in [2]. These include a generalized version of the OS-CFAR, CFAR detection in K-distributed clutter and performance of CFAR detection algorithms when clutter transitions are not abrupt.

When observations at peripheral detectors are continuous-time, they need to be sampled. One important issue is the design of sampling schemes at the peripheral sensors. An option is to employ uniform sampling but it is not necessarily optimum. Also, sampling schemes designed to ensure signal reconstruction with minimal loss due to sampling may not be the best when used in signal detection systems. We considered the problem of sampling design for Gaussian signal detection problems. Due to the analytical intractability of the probability of error criterion, our approach was based on the class of Ali-Silvey distance measures. Sampling points were determined that maximized the Ali-Silvey distance measure between the class conditional densities. Specifically, the Bhattacharyya distance, the I-divergence, the J-divergence and the Chernoff distance were used. The known signal case and the random signal case under strong signal assumptions were considered. These results are available in [3]. Effort on the design of sampling schemes for weak signal conditions was initiated and the results will be reported in the future. A number of other results obtained under the AFOSR sponsorship appeared in [4-8].

Concepts generated and experience gained while working on CFAR detection problems were extensively used in a joint project with Rome Laboratory and Kaman Sciences Corporation. This project dealt with the development of an expert system CFAR (ES-CFAR) processor. False alarms are a significant problem in wide area surveillance radar such as the U.S. Air Force E-3A Airborne Warning and Control System (AWACS). The conflicting requirements for a high probability of detection and a low probability of false alarm are rarely met due to a dynamically changing environment. Most CFAR detection algorithms assume a homogeneous Gaussian thermal noise like background. This assumption is frequently violated due to clutter variations including edges and multiple targets. Many CFAR algorithms have been developed to address these issues but one at a time. Therefore, any single algorithm is not likely to be adequate in a nonstationary environment. In this project, the approach was to intelligently select the CFAR algorithm or algorithms being executed at any time, based upon the observed characteristics of the environment and then use the results to yield the final decision. We used our results to formulate rules to be used in the ES-CFAR. A prototype system was developed and installed at the Rome Laboratory. The system has been tested with simulated data and recorded measurement data from an airborne radar system. Substantial performance improvement over a conventional baseline CFAR processor has been demonstrated. In addition to the ES-CFAR project, collaboration with a number of Rome Laboratory engineers took place. Some of these are Dr. J. Michels (multichannel detection algorithms), Mr. S. Borek (ambiguity function analysis), Mr. M. Wicks (CFAR algorithms), Mr. D. Ferris (detection and estimation for IR imagery), and Dr. V. Vannicola (sensor fusion).

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